

ASPHALT-RUBBER STRESS ABSORBING MEMBRANE AND ASPHALT-RUBBER STRESS ABSORBING MEMBRANE INTERLAYER

600.1 DESCRIPTION:

This item shall consist of a bituminous surface Stress Absorbing Membrane (SAM) or Stress Absorbing Membrane Interlayer (SAMI) composed of a single application of asphalt-rubber material and pre-coated aggregate in accordance with these specifications.

600.2 MATERIAL COMPONENTS:

A. Asphalt Cement:

The type and grade of asphalt cement utilized to manufacture the asphalt-rubber binder shall be AR-4000, AR-8000 or Performance Graded (PG) asphalt cement, which shall comply with requirements on the Table No. 600.1.

Table No. 600.1

* Asphalt Cement Grading Requirements

Climate	AASHTO M226 ASTM D 3381	AASHTO M 20 ASTM D 946	SHRP Grading Requirements
Cold	AC2.5, AC-5 or AC-10 AR-2000	120-150 or 200-300	PG 52-28
Moderate	AC-5 or AC-10 AR-2000 or AR-4000	85-100 or 120-150	PG 58-22
Hot	AC-10 or AC-20 AR-4000 or AR-8000	60-70 or 85-100	PG 64-16 PG70-10

* The exact grade of asphalt cement shall be determined by the asphalt-rubber supplier dependant of the specific project requirements and conditions (Climate and Traffic).

B. Asphalt Modifier:

The asphalt modifier, if required, will be a resinous, high flash point, aromatic hydrocarbon compound and shall conform to the requirements in Table No 600.2.

Table No. 600.2

Asphalt Modifier Requirements

Test Parameter	ASTM Designation	Requirement
Viscosity, cSt. At 212° F 100° C)	D 445	X+/- 3 *
Flash Point, COC, degrees F (C)	D 92	410° F (210° C) minimum
Molecular Analysis: Asphaltenes, percent by weight	D 2007	0.1 maximum
Aromatics, percent by weight	D 2007	55 minimum

- The symbol "X" is the viscosity of the asphalt modifier the Contractor proposes to the finish. The value of "X" which the Contractor proposes shall be between 19 and 36, and shall be submitted in writing to the Engineer. Any proposed changes to these requirements requested by the Contractor, in the value "X" shall require a new asphalt-rubber binder design.

C. Granulated Reclaimed Tire Rubber and High Natural Rubber (CRM):

The CRM used shall be produced primarily from the processing of automobile and truck tires. The rubber shall be produced by ambient temperature grinding processes only. The high natural CRM (if required), shall consist of ground or granulated rubber derived from materials that utilize high natural rubber sources. The gradation of both types of CRM when tested in accordance with ASTM C-136 (dry sieve only) and using a 50-gram sample, shall meet the requirements in Table No. 600.3.

Table No. 600.3
CRM Grading Requirements

Sieve Size	Reclaimed Tire CRM Percent Passing	High Natural CRM Percent Passing
#8 (2.36 mm)	100	100
#10 (2mm)	98 - 100	100
#16 (1.18 mm)	45 - 75	95 - 100
#30 (600 µm)	2 - 20	35 - 85
#50 (300 µm)	0 - 6	10 - 30
#200 (75 µm)	---	0 - 1

The use of CRM from multiple sources is acceptable provided that the overall blend of rubber meets the gradation requirements.

The individual CRM particles, irrespective of diameter, shall not be greater in length than 3/16 of an inch (5mm).

The CRM shall have a specific gravity of between 1.10 and 1.2 as determined by California Test #208, and shall be free of loose fabric, wire, and other contaminants except that up to 4 percent (by weight of rubber) calcium carbonate or talc may be added to prevent the rubber particles from sticking together. The rubber shall be sufficiently dry so as to be free flowing and not produce a foaming problem when blended with the hot asphalt cement. The CRM shall be accepted by certification from the rubber supplier. The Reclaimed Tire CRM Material shall conform to the chemical analysis in Table No. 600.4 and the High Natural Rubber CRM shall conform to the chemical analysis in Table No. 600.5.

Table No. 600.4
Reclaimed Tire CRM Chemical Requirements

Test	ASTM Test Method	Minimum	Maximum
Acetone Extract	D 297	6.0%	16.0%
Ash Content	D 297	---	8.0%
Carbon Black Content	D 297	28.0%	38.0%
Rubber Hydrocarbon	D 297	42.0%	65.0%
Natural Rubber Content	D 297	22.0%	39.0%

Table No. 600.5
High Natural Rubber CRM Chemical Requirements

Test	ASTM Test Method	Minimum	Maximum
Acetone Extract	D 297	4.0%	16.0%
Rubber Hydrocarbon	D 297	50.0%	----
Natural Rubber Content	D 297	40.0%	48.0%

D. Asphalt-Rubber Binder:

The temperature of the blended paving grade asphalt cement and asphalt modifier (if required) shall not be less than 375° F (190° C) nor more than 425° F (219° C) when the CRM is homogenously blended in the field. The combined materials shall be reacted for a minimum of 45 minutes after the incorporation of all the CRM. The asphalt-rubber binder shall meet the following criteria in Table No. 600.6, when the reaction is complete.

Table No. 600.6
Specification Limits for Asphalt-Rubber Binder

		Hot Climate	Moderate Climate	Cold Climate
Apparent Viscosity, 347° F (175° C) Spindle 3 @ 12 RPM: cps (ASTM D2669)	Min Max	1500 3500	1500 3500	1500 3500
Penetration, 77° F (25° C), 100 g, 5 sec; 1/10 dm (ASTM D 5)	Min Max	20 75	50 100	75 150
Penetration, 39.2° F (4° C), 200g, 60 sec; 1/10 dm (ASTM D 5)	Min	10	15	25
Softening Point, °F (°C) (ASTM D 36)	Min	135° F (57° C)	130° F (54° C)	125° F (52° C)
Resilience, 77° F (25° C), % (ASTM D 3407)	Min	30	25	15

Climate Definitions

Hot Climate	Average July Max @ Average January Low @	110° F (43° C) 30° F (-1° C) or above
Moderate Climate	Average July Max @ Average January Low @	100° F (38° C) 15 - 30° F (-9 to -1° C)
Cold Climate	Average July Max @ Average January Low @	80° F (27° C) 15° F (-9° C) or lower

The viscosity shall be conducted by using a hand held HAAKE VISCONETER: Model VT-02 with rotor 1, 24 mm in depth x 53 mm in height, or equivalent. The reacted asphalt-rubber binder shall be maintained at a temperature of not less than 375° F (190° C) nor more than 425° F (219° C).

If any of the material in a batch of asphalt-rubber binder is not used within six hours after the reaction period is complete, heating of the material shall be discontinued. When the asphalt-rubber binder temperature cools below 375° F (190° C) and is reheated, it shall be considered a reheat cycle. The total number of reheat cycles shall not exceed two (2). The binder material shall be uniformly reheated to a temperature of not less than 375° F (190° C). Additional scrap tire CRM may be added to the reheated asphalt-rubber binder and reacted for a minimum of 30 minutes and shall not exceed 10 percent of the total binder weight. Reheated asphalt-rubber binder shall conform to the requirements for blended asphalt-rubber.

E. Asphalt-Rubber Binder Formulation:

The asphalt-rubber supplier shall furnish to the Engineer within 15 days of the Notice to Proceed, the asphalt-rubber binder formulation which shall contain the following information:

Asphalt Cement:

Source of Asphalt Cement

Grade of Asphalt Cement

Percentage of Asphalt Cement by total weight of asphalt-rubber mixture.

Asphalt Modifier (if required)

Source of Modifier

Source of Modifier

Percentage of Modifier by total weight of asphalt-rubber mixture.

Reclaimed Tire Rubber (CRM)

Source of CRM

Grade of CRM

Percentage of CRM by total weight of the asphalt-rubber mixture

High Natural Rubber (CRM) (if required)

Source of CRM

Grade of CRM

Percentage of CRM by total weight of the asphalt-rubber mixture

If CRM from more than one source is to be utilized, then the above information will be required for each type of CRM used.

F. Aggregate Cover Material:

Aggregate shall be composed of clean and durable crushed rock or crushed gravel conforming to the following requirements:

Proposed aggregate samples shall be submitted to the asphalt-rubber supplier prior to the preparation of the mix design to test the aggregate for stripping characteristics. All testing results shall be submitted to the Engineer.

If the aggregate is to be crushed stone, it shall be manufactured from sound, hard, durable material of accepted quality and crushed to specification size. All strata, streaks, and pockets of clay, dirt, sandstone, soft rock, or other unsuitable material accompanying the sound rock shall be discarded and not allowed to enter the crusher.

If the aggregate material is to be crushed gravel, it shall consist of hard, durable fragments of stone or gravel of acceptable quality and crushed to specification size. All strata, streaks, pockets of sand, excessively fine gravel, clay, or other unsuitable material including all stones, rocks,, and boulders of inferior quality shall be discarded and not allowed to enter the crusher. The crushing of the gravel shall separate the #4, 3/8 and 1/2 inch (4.75, 9, and 12 mm) sieves and shall have a minimum 95% of the particles

with a minimum of one fractured face and 90% of the particles shall have a minimum of two fractured faces.

The crushed aggregate shall not contain more than 8% by weight of flat or elongated pieces and shall be free from wood, roots, and vegetable or other organic extraneous matter. The crushed coarse aggregate shall have a percentage of wear not more than 7 at 100 revolutions and not more than 30 at 500 revolutions, as determined by California Test #211.

Film Stripping will be determined according to California Test #302 and shall not exceed 25. Cleanness Value will be determined according to California Test #227 and shall have a minimum value of 80. The Durability will be determined according to California Test #229 and shall have a minimum value of 52.

The aggregate shall show no evidence of disintegration or show a total loss greater than 12% when subjected to 5 cycles of the sodium sulfate accelerated soundness test specified in ASTM C88.

The crushed aggregate for asphalt-rubber applications shall meet the requirements for gradation given in Table No. 600.7, when tested in accordance with ASTM C136.

Table No. 600.7
Aggregate Gradation Requirements
3/8 inch SAM & SAMI Aggregate Gradation 1/2 inch SAM & SAMI Aggregate Gradation

Sieve Size	Percent Passing	Sieve Size	Percent Passing
1/2 inch (12mm)	100%	3/4 inch (15mm)	100%
3/8 inch (9mm)	70 - 85	1/2 inch (12mm)	95 - 100
1/4 inch (4.75mm)	0 - 15	3/8 inch (9mm)	70 - 85
#8 (2.36mm)	0 - 5	1/4 inch (4.75mm)	0 - 15
#200 (75 µm)	0 - 1	#8 (2.36mm)	0 - 5
---	---	#200 (75 µm)	0 - 1

The aggregate shall be pre-coated or hot pre-coated with 0.5 ± 0.25 percent emulsified asphalt or paving grade asphalt cement. The Engineer shall determine the appropriate amount of pre-coat. The pre-coated aggregate shall have a "salt and pepper" appearance and when used hot shall be supplied to the project site at 250° F to 325° F (121° C to 162° C).

600.3 Equipment:

A. General:

The equipment used by the Contractor for pavement cleaning and excess aggregate removal shall include a self-propelled rotary power broom, mobile pick-up broom or top dumping mobile pick-up broom.

B. Asphalt-Rubber Equipment:

All equipment utilized in the production and application of asphalt-rubber materials shall be described as follows:

1. An asphalt cement heating tank with a hot oil heat transfer system or a retort heating system capable of heating the asphalt cement to the proper temperature for blending with the CRM.
2. An asphalt-rubber mechanical blender shall have a two stage continuous mixing process capable of producing a homogenous blend of asphalt cement and CRM, at the mix design specified ratios, as directed by the Engineer. The unit shall be equipped with a granulated rubber feed system capable of supplying the asphalt cement feed system, so as not to interrupt the continuity of the blending process.
3. The maximum capacity of the primary blending vessel shall be 500 gallons (1900 liters). Both the primary and secondary blenders shall be equipped with an agitation device orientated horizontally in the blending vessel. The blending unit shall be capable of fully blending the individual rubber particles with the asphalt cement. Separate asphalt cement feed pump and finished product pump are required. This unit shall have an asphalt cement totalizing meter in gallons and a flow rate meter in gallons per minute.
4. A trailer mounted self-powered distributor truck equipped with a heating unit, and an internal mixing device capable of maintaining a uniform mixture of asphalt cement and CRM. It shall be equipped with a full circulating spreader bar and pumping system capable of applying asphalt-rubber material within ± 0.05 gallons per square yard tolerance of the specified application rate, and must achieve a uniform covering of the surface to be treated. The distributor shall have a boot board on the rear of the vehicle and a boot-man shall accompany the distributor. The boot-man shall ride in a position so that all the spray bar tips are in full view and readily assessable for unplugging, if a plugged tip should occur. The distributor shall also include a tachometer, pressure gauge, a volume-measuring device, thermometer and shall also have a computer rate control (CRC) installed.

C. Aggregate Cover Material Spreader:

The cover material (chip) spreader shall be a self-propelled machine with an aggregate receiving hopper in the rear, belt conveyers to carry the pre-coated aggregate to the front, and a full width spreading hopper. The spreader shall be in good mechanical condition and be capable of applying the cover aggregate uniformly across the spread width and at the specified application rate. When utilizing hot pre-coated aggregate, heat-treated belts should be installed on the chip spreader.

D. Rolling Equipment:

A minimum of three operational self-propelled pneumatic-tired rollers shall be used for the required rolling of the cover material. The pneumatic-tired rollers' shall carry a minimum loading of 3,000 pounds (1361 kg) on each wheel at a minimum pressure of 90 pounds per square inch in each tire.

E. Hauling Equipment:

Trucks for hauling the cover aggregate shall be tailgate discharge and shall also be equipped with a device to lock onto the hitch of the cover material spreader. Haul trucks shall also be compatible with the cover aggregate spreader so that the dump bed will not push down on the spreader when fully raised, or have too short of a bed which results in aggregate spillage while dumping into the receiving hopper.

600.4 Construction Methods:

A. General:

Immediately prior to the application of the asphalt-rubber membrane, the surface shall be thoroughly cleaned in order to insure adequate adhesion of the asphalt-rubber to the existing pavement surface.

B. Weather Conditions:

Asphalt-Rubber material shall be applied only when the existing surface is dry and the atmospheric temperature is above 55° F (13° C) and rising. No material shall be applied when rain is imminent or when the wind is excessive.

C. Asphalt-Rubber Mixing and Reaction:

The percentage of Reclaimed Tire Rubber CRM shall be 15-20 percent by weight of the total asphalt-rubber mixture; the exact CRM content shall be determined by the binder design submitted by the asphalt-rubber supplier. During membrane placement the CRM percentage shall not fluctuate by more than 1 (one) percent by weight of total asphalt-rubber mixture. The High Natural CRM shall be 2 - 6 percent, which will replace an equal percentage of the Reclaimed Tire Rubber CRM.

The temperature of the asphalt cement shall be between 375° F and 450° F (190° C and 231° C) at the addition of the CRM. The asphalt cement shall be combined and mixed together in the asphalt-rubber blending unit and reacted in the distributor or a reaction vessel for a minimum period of 45 minutes from the time the CRM is added to the asphalt cement. The temperature of the asphalt-rubber mixture shall be above 350° F (176° C) during the reaction period, but shall not exceed 450° F (231° C) at any time. Exceeding the 450° F (231° C) limit will be grounds for rejection of the affected binder material.

When a job delay occurs after full reaction, the asphalt-rubber may be allowed to cool. The asphalt-rubber binder shall be re-heated slowly just prior to application to a temperature between 350° F and 400° F (176° C and 204° C). An additional quantity of asphalt cement and / or CRM may be added as required to produce a material with the appropriate viscosity. See reheat cycle in Caltrans Standards.

D. Application of Asphalt-Rubber Binder:

Placement of the asphalt-rubber membrane shall be blended only under the following conditions:

5. The pavement surface temperature shall be 50° F (10° C) and rising.
6. The pavement surface is clean and dry.
7. The wind conditions are not excessive.
8. All of the construction equipment such as the asphalt-rubber distributor, aggregate spreader, and haul trucks loaded with cover material, rollers and brooms are in position and ready to commence placement operations.
9. Rain is not imminent.

The asphalt-rubber mixture shall be applied to the roadway immediately following mixing and reaction at a temperature of 350° F and 400° F (176° C to 204° C) at a rate of 0.55 to 0.75 gallons per square yard (2.42 to 3.30 liters per square meter). Transverse joints shall be constructed by placing building paper across and over the end of the previous asphalt-rubber application. Once the application has progressed beyond the paper, the paper shall be removed immediately and disposed of as directed by the Engineer. The use of paper may be discontinued if the Contractor chooses to squeegee the excess asphalt-rubber binder material at the transverse joints prior to the placement of the cover aggregate. All longitudinal joints shall not exceed a 12 inches (30 cm) overlap.

Distributor bar height, distribution, speed and shielding materials shall be utilized to reduce the effects of excess wind upon the spray distribution (fan). The Engineer shall delay or reschedule work when high gusting or dirty wind prevent or adversely affect binder or aggregate application.

The application of asphalt-rubber binder to areas not accessible with the distributor bar on the distributor truck shall be accomplished by using pressurized hand wands or other means approved by the Engineer.

The Contractor shall comply with all Federal, State, and Local environmental laws, regulations and ordinances including but not limited to air quality requirements.

E. Application of Aggregate Cover Material:

Cover material shall be applied immediately onto the asphalt-rubber membrane, after application, at a rate of 26 to 34 pounds per square yard (11.79 to 15.42 kilograms per square meter). The actual amount selected within this range will be determined in the field based on the appearance of the SAM after initial rolling. At all times the application rate shall be kept to a minimum.

At the time of the application when using hot pre-coated aggregate the temperature of the aggregate shall range from 250° F to 325° F (121° C to 162° C).

F. **Rolling:**

At least three operational pneumatic-tired rollers and one steel wheel roller as directed by the Engineer, shall be utilized. Usage of the steel wheel roller should be based on the hardness value of the aggregate material. Sufficient rollers shall be provided to accomplish the required embedment of the aggregate cover material. At some project locations, or when production rates dictate, additional or fewer rollers may be utilized as directed by the Engineer. At no time shall there be less than 3 (three) operational pneumatic-tired rollers and 1 (one) 12 to 14 ton operational steel wheel roller on a project.

Sufficient rollers shall be used for the initial rolling to cover the width of the aggregate spread with one pass. The first pass shall be made immediately behind the cover material spreader as the aggregate is being placed. If the spreading is stopped for an extended period, the cover material spreader shall be moved ahead or off the side so that all cover material may be immediately rolled. Three complete passes with rollers shall be made with the pneumatic-tired rollers and one pass with the steel wheel roller.

G. **Flush Coat:**

For SAM applications, a fog seal or flush coat shall be applied during the same day of the placement of the SAM. The surface shall be dry and free of loose material at the time of application. This time-frame may be extended by the Engineer when weather and / or traffic conditions are not favorable. The flush coat shall not be applied when the surface is wet or when there is threat of rain. The ambient temperature shall be at a minimum of 70° F (21° C).

Asphaltic emulsion shall be grade CSS1, CSS1H or CQS1H diluted 50/50 with water shall be used for the flush coat. Immediately before applying the emulsion, the area to be flushed shall be cleaned of all loose aggregate and foreign material. This will be accomplished by power brooms or pick-up brooms and supplemented by hand brooms when necessary.

The diluted asphalt emulsion shall be well mixed before application and shall be applied by a distributor truck, in sound mechanical condition, at a rate of 0.10 to 0.2. gallons per square yard (0.44 to 0.88 liters per square meter), allowing for a residual after the emulsion "breaks" of 0.03 to 0.06 gallons per square yard (0.11 to 0.23 liters per square meter).

H. **Sand Cover:**

Sand cover material, **if required**, shall conform to the fine aggregate grading requirements in Section 90-3.03, "***Fine Aggregate Grading***", of the Caltrans Standard Specifications and these Special Provisions. Sand shall be free from any clay or organic material.

Sand shall be spread by means of a self propelled chip spreader equipped with a computerized device that will allow for application of the sand at a uniform rate over the full width of a traffic lane in a single application. Sand shall be spread at a rate of 2 to 4 pounds per square yard (0.91 to 1.81

kilograms per square meter). The exact rate will be determined by the Engineer. If approved by the Engineer other equipment may be used to spread the sand.

I. **Traffic Control:**

Except when it is necessary that hauling equipment must travel on the newly applied SAM, traffic of all types shall be kept off the membrane until it has had time to set properly. The speed of the hauling equipment shall not exceed 15 miles per hour (24 kilometers per hour) when traveling over a membrane that has not had sufficient time to properly set.

600.5 Method of Measurement:

A. **Asphalt-Rubber Bituminous Material:**

The asphalt-rubber bituminous Material shall be measured by the ton (by the kilogram) and shall be the actual weight in tons (kilograms) of material used in the accepted work by the Engineer.

B. **Cover Aggregate Material:**

The quantity of the cover aggregate material shall be measured by the square yard (square meter) and as accepted by the Engineer.

C. **Flush Coat:**

The emulsified asphalt material, diluted 50/50, shall be measured by the ton (by the kilogram) at the specified application rate and as accepted by the Engineer.

D. **Sand Coat:**

The quantity of the sand cover material shall be measured by the square yard (square meter) and as acceptable by Engineer.

600.6 Basis of Payment:

Payment shall be made at the contract unit price per ton (per kilogram) for asphalt-rubber bituminous material used in the SAM application and per square yard (per square meter). The emulsified asphalt flush coat shall be paid for by the ton (per kilogram) at the specified application rate. These prices shall be full compensation for furnishing all materials and for all preparation, hauling, and application of the materials, including labor, equipment and incidentals necessary to complete the item.